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These are the more important points I have been enabled to make out regarding this genus as established by Forbes, and, taking into consideration the close approximation, almost amounting to identity in form, which exists between these and the Sertularia, their mode of growth, as far as we can judge, and place of occurrence, being so similar,—so much so that a superficial examination would lead one to pronounce them identical,—I think we are justified in considering these rather Sertularian Polypidoms than Polyzoan Cænæcia,—a view of the genus which, I am convinced, further research among living forms will eventually prove to be the correct one.

G. Johnstone Stoney, A. M., read the following—

### NOTES ON THE MOLECULAR CONSTITUTION OF MATTER. NO. I.

The extraordinary power of the general method in Mechanics which we owe to the genius of Lagrange has tempted several mathematicians to try its strength in studying the unknown forces which enter into the molecular constitution of matter. In the applications of this method which have been hitherto made, as well as in other mathematical investigations into molecular forces,* the body under consideration has been supposed in its usual condition to consist of molecules:—

1°. At rest—

2°. Resembling one another, and similarly placed, each acting on its neighbours within a certain range—

3°. By forces adequately represented by functions multiplying the masses of the attracted and attracting molecules—

And which are such that the action on any one molecule may be represented by integrals extended through the sphere of action. In order that these integrations may be legitimate, it is necessary—

4°. That the sphere of action round each molecule include an immense number of other molecules, no one of which contributes more than an infinitesimal part to the total action on the central one; and—

5°. That the contributions from any two consecutive molecules be almost undistinguishable either in direction or amount.†

These hypotheses involve some remarkable results, the examination of which will enable us to limit the area of our search in prosecuting the study of molecular physics.

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* See Cauchy: "Sur l' équilibre et le mouvement d'un système de points matériels sollicités par des forces d' attraction ou de repulsion mutuelle."—Cauchy's *Exercises de Mathematiques*, tom. iii., p. 202; and "De la Pression ou Tension dans un Système de points materiels."—*Ib.*, p. 224. Navier: "Sur les lois du mouvement des fluides."—*Memoires de l'Institut*, tom. vi., p. 389; and "Sur les lois de l'équilibre et du mouvement des corps solides élastiques."—*Ib.*, tom. vii., p. 375. Poisson: "Sur les équations générales de l'équilibre et du mouvement des corps solides élastiques et des fluides."—*Journal de l'Ecole Polytechnique*, Cahier xx., p. 1. Haughton: "On the Equilibrium and Motion of Solid and Fluid Bodies."—*Trans. Royal Irish Academy*, vol. xxi., part 2. Jellett: "On the Equilibrium and Motion of an Elastic Solid."—*Ib.*, vol. xxii., part 3.

† The last two hypotheses, which must be insisted on if the method of integration be

I°. Conceive a medium of uniform density within a closed space, and possessing a constitution fulfilling the conditions required by these hypotheses. Conceive within this medium a canal of finite and uniform section which returns into itself. There will then be nothing to prevent the part of the medium which is within this canal from yielding to any force tending to make it glide lengthways. It is evident from hypotheses (4) and (5) that no obstacle to this motion will arise from the molecular forces acting on the superficial portions of the canal, and, *à fortiori*, that none will arise from those acting farther within it. Hence, the medium is a fluid.

II°. Again, conceive the medium within the closed space to consist of two parts of different densities in contact with one another. Then, in order that it may be capable of retaining a constitution such as is supposed, the molecular forces must be such as will make the part of greater density diffuse into the other. For the sphere of action round some molecules will consist of two segments of unequal density. Now, a segment of the greater density must exert either a greater attraction on the central molecule than an equal and similarly situated segment of less density or a greater repulsion. For if it exerted neither, it would follow, from hypotheses (3), (4), and (5), that the density might be increased or decreased to any extent without opposition from the molecular forces,—a state of things wholly unknown in nature. Again, it cannot have a greater attraction; for it would follow that, even if the conditions at the surface of a uniform medium could be such as to establish a state of equilibrium, this equilibrium could only be unstable; so that on the most trifling inequality of density occasioned by a deranging cause, the parts of less density would flow into those of greater; so that the whole medium would ultimately collapse into one or more points, or until some forces not consistent with the hypotheses came into play; or else it would get into a state of permanent internal motion inconsistent with hypothesis (1). The only remaining alternative,[*] that the segment of greater density exercises a greater *repulsion*, leads to no such impossible results. It might only require the parts of greater density to flow towards those of less, and thus make a state of uniform density one of stable equilibrium with a pressure against the containing vessel. Hence the medium is an *elastic* fluid or a gas.

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adopted, exclude many continuous functions; thus, using $F$ to denote the mutual action of two molecules, and $r$ for the interval between them, if the law of force be such that $r^2 F$ becomes infinite for $r = 0$, the central elements of the integral will contribute unduly to it, so that such a value as—

$$F = \mu \frac{a^2}{r^2} \left\{ 1 - A \frac{a}{r} + B \frac{a^2}{r^2} - \&c. \right\},$$

where $\mu$ is the coefficient of gravity, $A$, $B$, &c., constants, and $a$ a line of fixed length, is not admissible if the method of integration be retained; yet this law, and others like it, would, it is evident, lead to several of the most obvious properties of matter.

[*] A *less* attraction or repulsion from a segment of *greater* density has not been considered, since it is at once inconsistent with hypothesis (3).

III°. Next let the medium be of uniform density within a closed space, and imagine any plane crossing this space; then the pressure per square inch of the part of the medium lying on one side of this plane against the part lying on the other side may be seen to be a function of the density as follows:—Let *m* be a molecule sufficiently near to the plane on one side to be within the range of molecular repulsion of particles lying at the other side, and describe round *m* a sphere including all the molecules which act on it. Part of this sphere will, therefore, lie beyond the plane, and from hypotheses (3), (4), and (5), we find that the action on *m* arising from that segment of the sphere will vary directly as the density; since to alter the density is the same thing as to increase or decrease in a fixed ratio the number of molecules acting from each element of volume of the segment. The same reasoning applies to the action from the second side of the plane on any other molecule on the first side which is sufficiently close; and as the number of molecules thus acted on will also increase directly as the density, and as the interpolated molecules will, from hypothesis (5), be acted on to the same amount, and in the same direction, as the original molecules between which they lie, it follows *that the pressure per square inch within the medium will vary as the square of the density.*[*]

IV°. This pressure will of course be transmitted to the walls of the containing vessel, so that it becomes necessary to consider the conditions which must hold at the boundary of the medium. For this purpose three cases must be distinguished. The first arises along the surface of contact of two media, which obey, in the forces which they exert on one another, conditions consistent with our hypotheses. In this case, if the density of either medium vary after a state of equilibrium has been established, that of the other must vary in like proportion, otherwise the medium of increased density will force back the other. Again, if the range or law of the *mutual* molecular action of the two media differ from what hold with respect to the action of the molecules of either medium among themselves, it is evident that the density of this medium cannot be uniform, but must be different from its average value in the vicinity of the other medium. This alteration in the density of the superficial stratum will react on the stratum behind, and so on, producing a strained condition of the density throughout the medium,[†] which would even in some cases go the length of occasioning the precipitation of that medium upon the surface of the other. Another case, which is quite distinct, will arise when the medium is confined by a containing vessel, the walls of which are both rigid and immovable, but which acts on the medium within, not merely from its superficial layer of molecules, but from all those lying within a certain distance of the surface in such a way that no one molecule of the containing vessel contributes more than an infinitesimal part to the effect on a molecule of the medium. Up to a certain density and pressure the medium will be contained by such a vessel; but as soon as the density is made to exceed this limit, the medium will begin freely to permeate the vessel, and escape. The remarks made with reference to the last case apply equally to the present one, so long as the medium continues of sufficiently low density to be restrained. The third case of limiting conditions arises where the medium is kept in by the wall of a containing vessel which it can neither press back nor penetrate. That this may be so, the outward motion of the *superficial* layer of molecules of the medium must meet with an absolute obstruction from the repulsion of the inner layer of molecules of the containing vessel. The forces thus coming into play would be at variance with hypothesis (4); on which account it is needless here to trace further the consequences of their action, several of which are, besides, sufficiently obvious.

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[*] In the particular hypothesis of modified action introduced by Professor Jellett there will be another term containing the fourth power of the density.

[†] Somewhat like the strains which are found to exist in substances which need careful annealing. Thus, it is well known that if a chip be broken from a sharply defining object-speculum or lens of a telescope, the strains which held the fragment in its place being annihilated, the distribution of the density and strains throughout the whole of the rest of the mass are so altered that the accuracy of the defining power is lost.

This kind of examination might, indeed, be continued almost indefinitely, and extended to the crystalline texture of the medium and other branches of the subject; but enough has been done for my present end, which is to draw attention to the fact, that *no known ponderable material* possesses a constitution of the kind which has been supposed, and, consequently, that we are forced to admit, as demonstrated, the following points with reference to this obscure branch of Physics:—

1°. That no known ponderable matter consists of a continuous substance similar in all its parts.

2°. That by continuing the subdivision of *solids*, as far as is consistent with the parts being similar, similarly placed, and acting alike, either the whole, or at least a controlling part, of the action on each such molecule must be contributed by a finite number of those in its vicinity. The validity of this conclusion is not disturbed by attributing to the elementary molecules such motions as may constitute sound, heat, light, and electricity, and the statement is evidently *à fortiori* true of the parts of the elementary molecules.

3°. If liquids are separable into elementary molecules of the kind described in the last paragraph, similar to one another, similarly placed and acting alike, then the statement of that paragraph may be repeated, word for word, with reference to them; but if, as seems perhaps more likely, there is going on between the elementary molecules of liquids a constant interchange of their parts, then the language must be somewhat modified, although the conclusion remains substantially the same.

The case of gases is somewhat different. The examination which has been made above shows, no doubt, in the case of gases, as it does for either solids or liquids, that their constitution cannot be that of a *stationary* system, each molecule of which acts, but to a trifling extent, on each of those around it. But it does not show that it may not be such a system in a state of vivid molecular motion. The closer investigation of this hypothesis opens a new branch of the subject. Already, however, a positive step appears to have been made by *demonstrating* that in solids and liquids each molecule is acted on to a finite extent by those in its immediate neighbourhood.

Sir William R. Hamilton read a paper, "On some Transformations of Diverging Lines."

A collection of twenty-five ancient articles, consisting of bronze pins of several forms, the axis of a spinning bobbin, and two needles, all found near Gweedore, county of Donegal, were presented.

### MONDAY, APRIL 26, 1858.

JAMES HENTHORN TODD, D. D., President, in the Chair.

J. BEETE JUKES, Esq., read a paper "On the Lower Palæozoic Rocks of the South-East of Ireland and their associated Igneous Rocks."

Rev. Professor Haughton read a paper on the same subject, and described certain minerals as abounding in these rocks, which had been hitherto unnoticed in common granites of Ireland.

The Secretary read a letter from the Chairman of the Local Committee at Baltimore, inviting the Members of the Academy to attend a Meeting of the American Association for the Advancement of Science, to be held in that city.

George V. Du Noyer, Esq., presented a series of drawings of antiquities, made by himself, from bronze and iron antiquities in the Museum at Rouen, in September last.

Fleetwood Churchill, M. D., on the part of Dr. Lockhart, presented five porcelain seals, collected by that gentleman during his residence in China. Two of them have inscriptions exactly the same as the seals Nos. 2 and 51 engraved in the late Mr. Getty's work on Chinese Seals found in Ireland.

The Secretary announced the presentation of a medal by the Royal Norwegian University of Christiania, struck in honour of Dr. Christopher Hansteen having completed a term of fifty years as Professor of Astronomy in that University.

### MONDAY, MAY 10, 1858.

JAMES HENTHORN TODD, D. D., President, in the Chair.

REV. CHARLES GRAVES, D. D., read a paper "On a System of Imaginaries analogous to those employed by Sir William R. Hamilton in his Calculus of Quaternions."

The PRESIDENT read the following paper—